NCSLI Measure

The Journal of Measurement Science

ISSN: 1931-5775 (Print) 2381-0580 (Online) Journal homepage: https://www.tandfonline.com/loi/ujms20

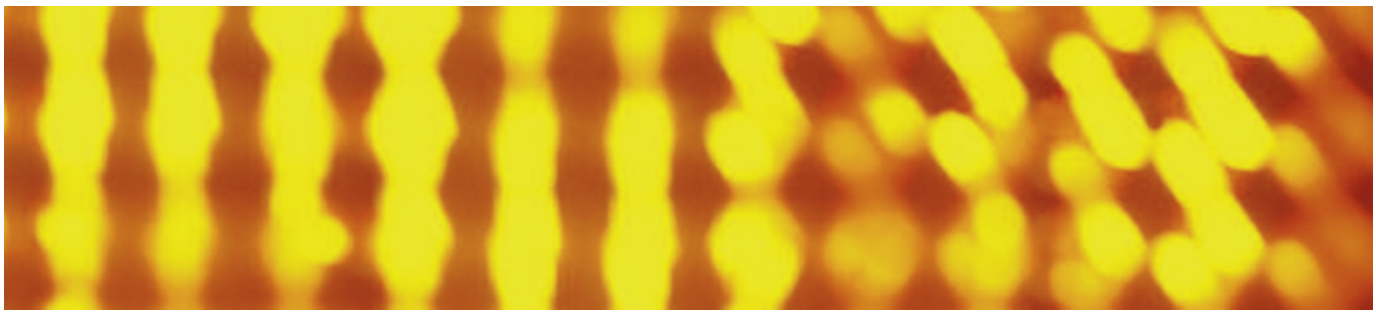
Comparing and Contrasting Studies of Metrology Education and Training in Europe and North America

Georgia Harris & Leslie R. Pendrill

To cite this article: Georgia Harris & Leslie R. Pendrill (2008) Comparing and Contrasting Studies of Metrology Education and Training in Europe and North America, NCSLI Measure, 3:2, 38-45, DOI: 10.1080/19315775.2008.11721423

To link to this article: https://doi.org/10.1080/19315775.2008.11721423

Published online: 12 May 2016.



Comparing and Contrasting Studies of Metrology Education and Training in Europe and North America[1]

Georgia Harris[2] and Leslie R. Pendrill[3]

Abstract: This paper compares and contrasts two studies of the status of metrology education and training completed within NCSL International (NCSLI) and Implementing the Metrology European Research Area (iMERA). The current formulation by NCSLI and its partners of a strategic roadmap for metrology education and training and a survey of accreditation body assessors are presented. In addition, a corresponding iMERA study in Europe of metrology knowledge transfer has been initiated in preparation for the new European Metrology Research Program. This paper compares and contrasts the approaches and the formulations of these project and concludes with suggestions for future cooperation. Both the NCSLI and iMERA studies have shown a coordinated forum is needed to ensure that metrology staffing requirements are met at all levels – i.e., competent personnel and the necessary resources to support them.

1. Introduction

"Education and training are perhaps the best solutions for ensuring accuracy and traceability" [1], according to the strategic roadmap for metrology education and training (E&T) at present being formulated in North America by NCSLI, together with the Measurement Science Conference and the American Society for Quality, Measurement Quality Division.

In parallel with this roadmap, a corresponding study in Europe of Metrology Knowledge Transfer (KT) [2] has been initiated in preparation for the new European Metrology Research Program. [3]

The present paper compares and contrasts the current approaches and formulations of these two studies and concludes with some suggestions for future cooperation.

Georgia L. Harris[2]
Weights & Measures Division
National Institute of Standards and Technology (NIST)
100 Bureau Drive MS 2600
Gaithersburg, MD 20899 USA
Email: gharris@nist.gov

Leslie R. Pendrill[3]
SP Measurement Technology
Box 857, SE-50115
Borås, Sweden

2. Metrology for Innovation and Trade

Reliable measurement results are important in almost every aspect of our daily life, ranging from fundamental science, through health and safety, to global trade.

It is therefore not surprising that one of the more essential ingredients in improving trade, innovation, growth and well-being is efficient transfer of measurement knowledge.

Alongside improving testing and calibration methods, new measurement knowledge created from metrology research can also be exchanged with stakeholders as a key action in enhancing measurement-related trade and innovation. Critical success factors, such as new knowledge creation and good knowledge transfer, are internationally recognized as essential in enhancing trade and innovation. [1, 3, 4]

[1] Paper presented at 2007 NCSL International Workshop & Symposium and won the Invited Best Paper Award.

[2] Georgia L. Harris is also the current NCSL International Vice President for Learning and Development. The ideas and concepts in this paper represent input previously gathered and published on behalf of NCSLI and do not represent the official positions of either NIST or NCSLI.

[3] Leslie R Pendrill is Head of Research at the division of Measurement Technology and the National Metrology Institute at SP Borås, Sweden. From January 1, 2008 Prof. Pendrill is the delegate for Sweden to EURAMET (www.euramet.eu) the European Association of National Metrology Institutes.

2.1 NCSLI Study of Metrology Education and Training

NCSLI, the Measurement Science Conference, and the American Society for Quality, Measurement Quality Division are working in collaboration to create a strategic roadmap for metrology education and training in North America and then to realize the plan. Table 1 provides a general overview of the eleven key items in the strategic challenges framework. One of the key strategic challenges is "Collaboration, in order to ensure that the entire metrology community and stakeholders work together to gain synergy in achieving our goals." Collaboration among people and organizations can be used to identify metrology education and training needs and to provide solutions in a cost-effective and efficient way in order to meet the "Metrology Education and Training Needs of the Future." [1, 5, 6]

1. Metrology & Standards Outreach		
Human Resources	*Education*	*Training*
2. Workplace Development 3. Professional Development	4. Formal Education Programs	5. Training Resources 6. Training Opportunities (Events) 7. Training Assessment
Infrastructure	8. Knowledge Management	
	9. Technology Trend Analysis	
	10. Collaboration	
	11. Funding	

Table 1. Key elements of the proposed strategic challenges in the NCSLI Metrology Training & Education roadmap.

2.2 European Study of Metrology Knowledge Transfer

The European Metrology Research Programme [3], which started in the spring 2007, is a major coordination of national metrology research programs with the aim of meeting increased demands for quality-assured measurements in both traditional and new technology areas. While research is the main focus of the program, studies of subsidiary activities, such as measurement knowledge transfer, have been made in the preparatory Networking of the European Research Area (ERA-NET) project iMERA [7], as reported at the 2006 NCSLI Conference. [8]

The following recommendations from the ERA-NET project about Metrology KT were made:

1. Metrology KT should be an important element in the European Metrology Research Programme since new measurement knowledge, created in research, needs to be transferred to be useful;
2. Metrology KT is a key factor in metrology's impact on modern society since better measurements are an essential component in promoting innovation, growth and welfare;
3. Metrology KT is a two-way information exchange between National Metrology Institutes (NMIs) and metrology stakeholders (universities, practitioners, industry, regulators); and
4. Metrology KT covers a wide range of measurement needs/subjects as well a broad spectrum of KT mechanisms.

These recommendations call for specific, proactive, and coordinated actions supporting Metrology KT in Europe, over and above the usual knowledge transfer activities attached to any project. [2]

NCSLI [5]	iMERA T1.4 KT [2]
Outreach: • Typical policy and decision makers, managers, and consumers have no understanding of metrology, quality, or standards infrastructure or of its value and indispensability. • No central "voice" for measurement community.	Metrology Knowledge Transfer: • Key factor in *metrology's impact on modern society* since better measurement is an essential component in promoting innovation, growth and welfare. • *Two-way information exchange* between NMIs and metrology stakeholders (universities, practitioners, industry, regulators).

Table 2. Comparison of views about Metrology Outreach in the NCSLI and iMERA studies of Knowledge Transfer.

3. Comparing Knowledge Transfer Studies

A complete tabulation of the NCSLI critical drivers [5] with those of both the iMERA T1.4 KT study [11] and the EURAMET INTMET KT Project [2] is given in Appendix A.

3.1 Critical Drivers

A number of critical drivers in the future development of Metrology KT, including outreach, human resources, KT subjects and modes, and infrastructure, were identified in the NCSLI study. [5] These critical drivers may be compared with key aims of a coordinated program in the corresponding European arena. [2]

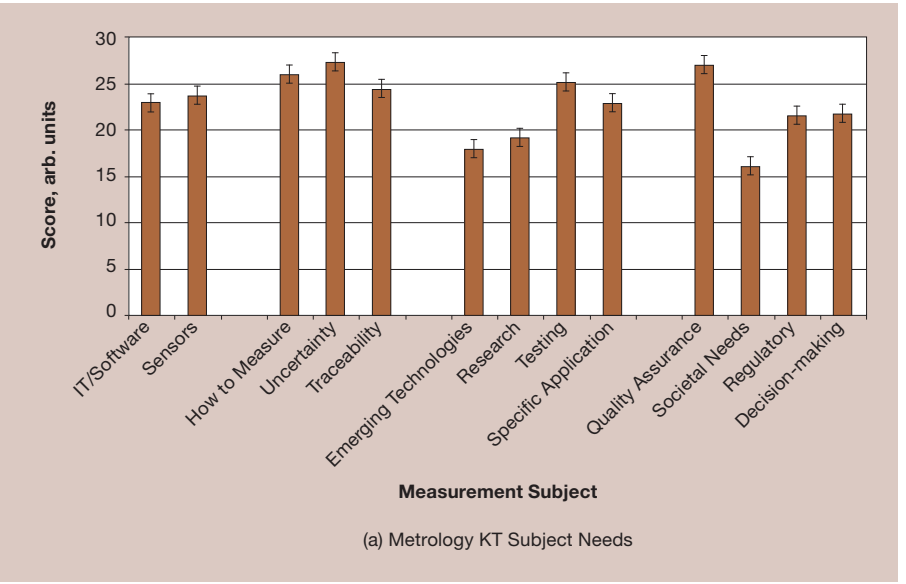
To exemplify the different perspectives of the NCSLI and European studies, Table 2 shows views concerning 'Outreach' as the first key element identified as a strategic challenge [Table 1]. Following a comparison of the ranking of Subjects and Modes of E&T in the next section, the rest of this section will review the overall similarities and differences between the studies.

3.2 Ranking of Subjects and Modes of E&T

In comparing these studies of Metrology KT, it is interesting that some of the results achieved in both Europe and North America include a ranking by industrial and NMI metrologists of both subjects and modes of metrology knowledge transfer. A comparison can be made between the North American survey results of the KT needs of American calibration laboratories [6] and the 2005 iMERA survey of the perceived educational needs of European metrology stakeholders [2] – see Appendix A, Subjects & Modes of Metrology Knowledge Transfer. For instance, both studies found that metrology concepts such as Traceability, Uncertainty and Accuracy

were highly rated by stakeholders, as shown in Fig. 1.

In Fig. 1(a), the order of Metrology KT subjects on the *x*-axis is meant to indicate the measurement 'value chain', that is, ranging from generic measurement technologies (on the left); through basic concepts, such as how to measure specific quantities and evaluate measurement uncertainty, to measurement in various fields of application, and finally in the context of conformity assessment. As may be seen in Fig. 1(a), there are no great differences overall amongst the various subjects in the need as perceived by European stakeholders. [2] Nevertheless, metrology training in the emerging technologies (such as bio-, nano-, etc.) and in societal needs are ranked significantly lower than, for example, training in measurement uncertainty and quality assurance, since the respective scores, including quoted confidence intervals, clearly do not overlap.



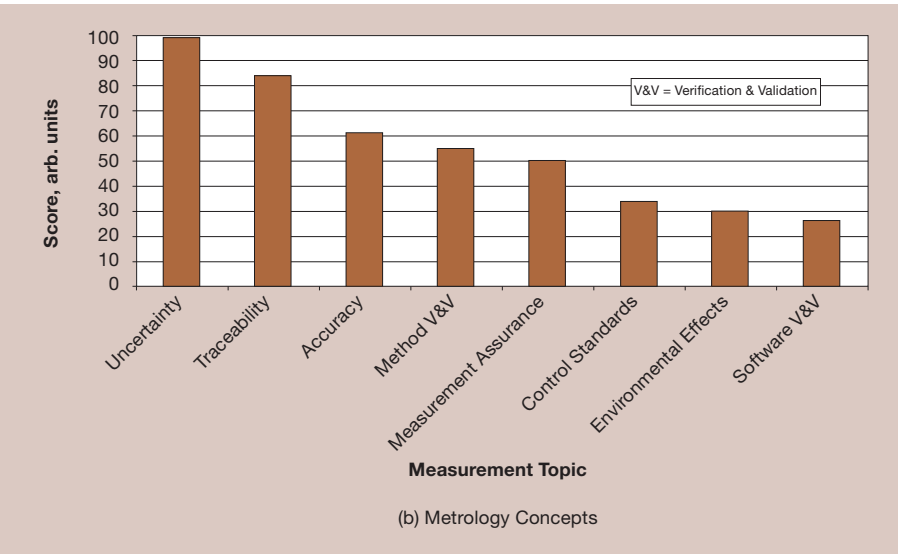


Figure 1. Stakeholders scoring of the needs of different Metrology KT subjects/topics (a) from European survey reference [2] and (b) from the NCSLI survey [6]. Note that error bars in (a) indicate 95 % confidence intervals for the scores; for details, see reference [2].

3.3 Common Themes Between the Studies

3.3.1 Identification of KT as a Critical Development Issue

As noted earlier, education and training are critical functions required to support innovation in trade. This common theme was clearly delineated in the NCSLI and iMERA/EURAMET[4] (European Collaboration in Measurement Standards) efforts [5, 2, and Appendix A, *Outreach*]. In fact, the case can be made that workforce development as a whole, in addition to education, training, and knowledge transfer, was identified as a critical issue among the world's measurement communities. Numerous organizations involved in metrology and standards, beyond those compared here, have identified workforce development and knowledge transfer issues as a part of their strategic efforts.

For example, here is an excerpt from the American National Standards Institute (ANSI), August 2000 study on the U.S. National Standards Strategy [9]:

> *Make the value of standards development both apparent and real by educating public and private sector decision-makers about the value of standards and how to take advantage of the process. It is clear that management in both the public and private sectors are not sufficiently aware of the benefits of external standardization, or their current reliance on voluntary consensus standards, even when they are vigorously implementing standardization programs in their internal operations. An organized education process will provide broader participation, more effective participants and higher quality standards.*

In addition, another excerpt from the recent Instrument Society of America (ISA) study [10]:

> *In February 2007, ISA leaders from across the globe met in North Carolina to discuss strategic issues surrounding the profession and industries in which automation professionals work. How can the next generation of engineers prepare themselves to lead in the automation profession? How can current*

[4] EURAMET is a formal association, founded 2007, among European National Metrology Institutes (formerly EUROMET, an informal association from 1987).

automation professionals incite them to pursue a career in the field? During the meetings, ISA President Steve Huffman, also Vice President of Mead O'Brien in St. Louis, Mo., and ISA Executive Director Patrick Gouhin led discussions on how ISA and other member organizations in The Automation Federation can facilitate workforce development through a coordinated strategy to advance the automation profession. "Projects such as K-12 education programs, university relations, model automation curriculum, CAP[5] and CCST[6] Associates, training, corporate membership, government relations, and diversity recruitment can serve the current professionals as well as the next generation workforce," Gouhin said.

3.3.2 Need for Collaboration

Both NCSLI and EURAMET organizations have clearly identified the need for collaborative efforts [1, 2, and Appendix A, *Infrastructure*]. NCSLI, which is an association of organizations, has begun partnering with other organizations that have similar needs, such as the Measurement Science Conference and the American Society for Quality, Measurement Quality Division. In addition, the NCSLI member organizations have begun collaborating on related projects. The entire iMERA and EURAMET efforts are joint collaborations among European countries in areas of metrology research and development. Knowledge transfer is one of the essential components in the European Metrology Research Program [3]. In a report of the T1.4 group, a question was raised: "What would a European Metrology KT program achieve which has significant added value to a mere collection of national programs?" One of the workshop outcomes was a coordination effort.

3.3.3 Need for Resources

Both organizations have clearly identified the need for external, and combined, resources to enable successful programs of addressing workforce development, education and training issues [Appendix A, *Infrastructure*]. A variety of resources have been identified as a part of the European Metrology Research Program [2]. NCSLI has identified one of the key drivers and strategic challenges as that of funding education and training initiatives. [1]

3.3.4 Need for Measures of Success

As both organizations seek to establish objectives and goals to address common needs, both are seeking the best ways to identify and quantify measures of success [Appendix A, *Human Resources* and *Infrastructure*]. Measuring the outcome of "a skilled, educated and trained workforce" as metrology requirements and technologies are rapidly changing requires both organizations to give critical consideration to what is success and how it is measured.

[5] CAP: Certified Automation Professional®

[6] CCST: Certified Control Systems Technician®

3.4 Differences Between the Studies

3.4.1 Role of the National Metrology Institutes

The European efforts are primarily driven by the National Metrology Institutes [3, 7]. Therefore, many of the perspectives and drivers are NMI-centric. That is, the NMIs have clearly taken a central role in ensuring effective metrology education and training, albeit consulting stakeholders to a certain extent. On the contrary, while the NMIs of North America have clearly been involved in the NCSLI efforts to create a strategic roadmap, the efforts were not driven by the NMIs. [1].

3.4.2 Subjects and Modes of Delivery

The initial E&T focus group workshops and surveys of NCSLI did not evaluate the role of the NMIs in the delivery of education and training. The NCSLI efforts only marginally assessed the subjects and modes of delivery. However, subsequent efforts to survey assessors of accreditation bodies identified a number of needs beyond education and training. It was noted that, in some cases, the best solution for improving specific workforce issues in accredited calibration laboratories might be "how-to" guides. The iMERA effort specifically addressed the role of the NMIs as a key partner in the delivery of knowledge through education, training, how-to guides, and cooperative research efforts. Brief examples were given in section 3.2.

3.4.3 Human Resources and Workforce Issues

The NCSLI is made up of primarily organizations with industry representation. As such, many of the issues regarding issues, such as recruiting, retention, and job descriptions, are specifically addressed in their efforts. Based on ongoing anecdotal feedback, hiring qualified staff is a critical issue in the United States and was a primary driver for initiating the NCSLI efforts. This impact was notably absent in the iMERA projects.

4. Conclusions

In comparing and contrasting recent European and North American studies of Metrology KT and E&T, some interesting differences and similarities were found. For instance there were differences in assessing the various strategic challenges, but similarities in stakeholders' perceived needs of measurement subjects in meeting future needs.

In the area of infrastructure supporting education and training, the NCSLI and iMERA studies both concluded that there is a need for a coordinated forum to make sure that the right people and resources are brought together so that metrology staffing needs are met at all levels.

5. Acknowledgments

The authors thank the European Commission for supporting the iMERA project (EU *contract no 016220*, project coordinator National Physical Laboratory - NPL) as an ERA-NET Coordinating Action under "Coordination of Research Activities" of the 6th Framework Specific Programme "Integrating and Strengthening the European Research Area" in which much of the European part of this work has been performed.

6. References

[1] G. Harris, "Education & Training: Collaboration on Needs Assessments and Solutions," *Presentation at 2007 Measurement Science Conference* (also *CENAM Metrology Symposium,* 2006.)

[2] L.R. Pendrill and G. Tellett, "Study of Metrology Knowledge Transfer in the European Research Area," deliverable D1.4 to iMERA, *SP Report* 2006:24, ISBN 91-85533-09-02. (Available from the SP Technical Research Institute of Sweden web site: www.sp.se/sv/units/measurement/Documents/Research/IMERA/iMERA-studie_av_M%C3%A4tteknisk_kunskaps%C3%B6verf%C3%B6ring_i_Europa.pdf)

[3] "European Metrology Research Programme: Outline," 2007, Edition – March 2007.

[4] DTI 2003 "Competing in the global economy: the innovative challenge," DTI Innovation Report (UK), December 2003. (Available at the NPL web site: www.npl.co.uk/met/dti_steer/innovation-report-full.pdf)

[5] G. Harris, "Serving the World of Measurement: Meeting Education and Training Needs of the Future," *NCSLI Strategic Roadmap for Metrology Education and Training,* 2005. (Available at the NCSLI web site: www.ncsli.org/current_events/ncsli-strategic-roadmap-metrology-training-education.pdf)

[6] G. Harris, "Report on NCSLI Accreditation Body Survey," *NCSLI Board of Directors Report,* 2007.

[7] iMERA 2005 "Implementing Metrology in the European Research Area." (Available from the EURAMET web site: http://www.euramet.org/index.php?id=projects)

[8] L.R. Pendrill, G. Tellett, A. Henson, and H. Källgren, "Metrology Knowledge Transfer in the European Metrology Research Programme," *2006 NCSLI Workshop and Symposium,* Nashville, TN, 2006.

[9] "National Standards Strategy for the United States," American National Standards Institute (ANSI), August 2000.

[10] E.F. Policastro, "Workforce Development on Main Menu at ISA," *InTech*, 01 March 2007. (Available at the ISA *InTech* web site: www.isa.org/InTechTemplate.cfm)

[11] Report from the iMERA project task T1.4 – "Study of Metrology Knowledge Transfer in the European Research Area," Workshop held in Berlin, December 2005.

7. Appendix A

I. OUTREACH		
NCSLI Critical Drivers	**iMERA T1.4 KT Study**	**EURAMET INTMET KT Project**
Outreach • The typical policy and decision makers, managers, and consumers have no understanding of metrology, quality, or the standards infrastructure or of its value and indispensability. • There is no central "voice" for the measurement community.	Metrology Knowledge Transfer is: • A key factor in *metrology's impact on modern society* since better measurement is an essential component in promoting innovation, growth and welfare. • A *two-way information exchange* between NMIs and metrology stakeholders (universities, practitioners, industry, and regulators).	***WP 3 Metrology KT & Innovation*** Better measurement is an essential component in promoting innovation, growth and welfare. This WP aims to explore existing and potential future actions where the principal aim of Metrology KT is innovation, rather than education or regulation. Actions could include mechanisms for metrology KT for innovation as well as impact assessment (including coordination with iMERA task T2.5 Addressing intellectual property issues and iMERA T1.5 Impact). ***WP 4 Metrology KT & Regulation*** Metrology KT is motivated in part by its support to the implementation of regulation (quality assurance, health & safety, infrastructure for innovation, trade, etc.). How can Metrology KT be improved in a dialogue with regulators – for instance, standardization bodies, accreditation bodies – and actors in quality-assured measurement and conformity assessment (secondary calibration laboratories, testing laboratories, notified bodies, etc)? Coordination with iMERA task T2.8 Ethical, Gender and Societal Issues.

II. HUMAN RESOURCES		
NCSLI Critical Drivers	**iMERA T1.4 KT Study**	**EURAMET INTMET KT Project**
Human Resources • There is a critical ongoing loss of metrology expertise (in the U.S.). • The changing demographics in science, technology, and engineering, (aging staff, retirements, loss of military personnel, lack of interest in these careers, smaller next generation, higher pay and glamour in other fields) along with the lack of a clear career path in metrology, is causing a shortage of qualified staff that will worsen. • There is a lack of educational depth and capacity in the less experienced personnel at all levels. • The current certification system (CCT) evaluates knowledge-based proficiency but not demonstrated competency.	Metrology KT across national boundaries is important for raising competitiveness across the EU.	

III. SUBJECTS AND MODES OF METROLOGY KT		
NCSLI Critical Drivers	**iMERA T1.4 KT Study**	**EURAMET INTMET KT Project**
Topics and Methods NCSLI follow-on study of accreditation body assessors addressed various topics and relative importance.	*Subjects and Modes* Metrology KT covers a wide range of measurement needs/subjects as well a broad spectrum of KT modes. ***Subjects*** of Metrology KT activities: • Measurement Quality • Measurement of Quantities • Measurement by Application • Measurement Systems	***Modes*** of Metrology KT activities: • Direct research collaboration with national metrology institute (NMI); • 'Metrology clubs' • Measurement guides/books • Measurement training provided by national metrology institute (NMI); university/institute; or commercial course provider • Measurement conferences/workshops/ summer schools • Interlaboratory comparisons (ILC, KC, PT,…) • Customer contacts • Standardization • On the job experience • Spin-off companies

IV. MODE OF METROLOGY KT: EDUCATION		
NCSLI Critical Drivers	**iMERA T1.4 KT Study**	**EURAMET INTMET KT Project**
Education • Limited number of degree programs in "metrology" that support the educational needs of the measurement industry. • More integration of metrology courses in other curricula is needed. • Inadequate collaboration and flexibility among providing institutions. • No recent curriculum assessments to ensure that the programs are meeting current needs; or plans for improvements and enhancements to meet future needs. No documented history of attempts at developing metrology programs.	Few universities have coherent metrology courses on their curricula, reflecting the cross-disciplinary aspect of metrology in cutting across traditional academic faculties.	***WP 6 Metrology KT & Education*** Metrology KT is part of wider educational and training activities in the European Union. Coordination between Metrology KT actions by NMIs with other actors in education and training is to be explored. Areas could include: inventory of university material for measurement teaching/KT; industrial training courses; continued support for European MÉTROLOGIE 2009 Congress; NCSLI conferences, etc.

V. MODE OF METROLOGY KT: TRAINING		
NCSLI Critical Drivers	**iMERA T1.4 KT Study**	**EURAMET INTMET KT Project**
Training • There has been no systematic assessment of what training is available and what training is needed, although the perception is that there are gaps and inadequacies (for both instruction and instructors). There has been no needs analysis; no gap analysis. • There is no system in place for assessing the quality or levels of technology, client needs, and instruction that are available. • There is no central resource for information on metrology training.	The high development costs of training and the development of guides, etc., is not being optimized at the European level.	***WP 7 Metrology KT Development of Material by NMIs*** Development of Metrology KT material in a coordinated action amongst NMIs. Areas could include: • Inventory of NMI material for teaching/KT; e-learning template for KT material • Need for European Metrology journal/newsletter/guides • Reassignments between NMIs and stakeholders (university, industry)

VI. MODE OF METROLOGY KT: COLLABORATION IN RESEARCH		
NCSLI Critical Drivers	**iMERA T1.4 KT Study**	**EURAMET INTMET KT Project**
	According to the results of the iMERA T1.4 KT European survey 2005, the preferred mode of Metrology KT for stakeholders is collaboration in research with an NMI. Stakeholders perceive the least beneficial KT activity to be academic training in metrology.	***WP 5 Metrology KT and Research*** Collaboration in research is one important mechanism of Metrology KT between NMIs and major research teams at universities, institutes, industries, etc. It enables the development of new SI definitions; metrology in the emerging technologies (bio, nano, etc.) and more. This WP explores means of making more effective coordinated mechanisms between NMIs and these major research teams, which to date have, however, been few and rather *ad hoc* International coordination with corresponding actions in CGPM/IUPAP, etc. *Deliverable:* Metrology KT Impact study (in coordination with iMERA T1.5). International conference on Physics & Metrology.

VII. INFRASTRUCTURE FOR METROLOGY KT		
NCSLI Critical Drivers	**iMERA T1.4 KT Study**	**EURAMET INTMET KT Project**
Infrastructure • There is no system to capture measurement knowledge and information and ensure its availability as needed. • There is no system that links upcoming technology trends with methods for ensuring that people are trained to support it. • There has not been a coordinated forum for ensuring that the right people and resources are brought together to ensure that metrology staffing needs are met at all levels. • There has not been a focused effort to ensure that funding for metrology education and training are available to meet the needs.	A specific, proactive coordinated action of Metrology KT in Europe is called for, over and above the usual knowledge transfer attached to any project. • An initial piece of work is looking at objectives, strategy, and operational framework and ensuring the work is inclusive, as well as setting success measures. There is need for some creativity since, to date: • Relatively few NMIs have dedicated KT staff and projects • There are different levels of engagement in the innovation agenda There is good support for taking KT forward into article 169 especially from those who would find it more difficult to engage in the research agenda.	***WP 1 Metrology KT Coordination*** Provide overall coordination of European Metrology KT Programme as mentioned in the EMRP [3]. Activities would include KT capacity building among NMIs; collaborative research including reassignment, etc. A new KT Group is proposed to be formed for this coordinated proactive European Metrology KT Programme. The Group will be populated by KT contact persons per NMI where available. An initial piece of work would look at objectives, strategy, and operational framework and ensure the work is inclusive, as well as set some success measures to be evaluated at the end. *Deliverable:* Coordination plan for Metrology KT in iMERA Art. 169/EMRP. ***WP 2 External Funding of Metrology KT*** A variety of potential sources of external funding/support for developing Metrology KT are available, including EU/Marie Curie/Science & Society, etc. *Deliverables:* Proposals to EU Marie Curie and other sources of funding.